HIGHWAY THREE-TIER SURFACE GEOGRID REINFORCED WALL: MONITORING

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Abstract: A new D1 highway designed near Sverepec village crosses the hilly country. The highway alignment connects two bridges on both sides of the narrow long valley. Because of the request to use the excavated soils from the nearby highway cuts, a new embankment was considered. According to the design, the surface of the new highway will be approximately 15 m above the current ground level. Two 12.0 m and 15.5 m high three-tier surface geogrid reinforced walls (TTGRW) have been designed as part of the highway embankment. The upper wall directly supports the highway pavement. The designer used full height precast concrete facing panels and geogrids directly anchored in the concrete. The full-strength geogrid connection between short starter geogrid length pre-cast into concrete panel and main geogrid length was designed.

Because of the fact, that this supporting system was used in Slovakia for the first time, there was a need to monitor performance of the wall. The paper describes results of this wall monitoring.

Two measuring profiles with up to 36 extensometers were designed in each measuring profile to monitor geogrid strains. Cable-extension position transducers were used to measure facing panel displacements within the whole construction period of the wall. These relative movements are compared to absolute movement of the wall-facing panel. After each load increment on the wall top during the construction process, the extensometers were read and the values recorded.

The paper reports the discussion of the geogrid behaviour from the measurement results. It contains an analysis of long-term geogrid deformations, individually on each tier. The areas with larger deformation occurrence are marked with strain isolines.

Keywords: geogrid reinforcement, long-term behaviour, monitoring, reinforced earth retaining wall, strain, uniaxial.

INTRODUCTION

On the D1 motorway between Ladce and Sverepec (municipalities), there is a set of elevated motorway bridges connected to a high embankment. The embankment is more than 12 m high. There is the Sverepecký Potok River on its SE side and the No. 61 national road has been left in its place on its NW side, immediately next to the embankment of the motorway in construction. In the narrowed profile, the motorway embankment gets into collision with the national road. The need to keep the national road in its place has caused that substantially less land was taken by the motorway. That requirement could be met in two ways: by a bridge or by a reinforced soil structure.

As the subject section was followed up by complex bridges at both its ends it was decided – taking into account is unusual height – to build a three-tier structure of reinforced retaining walls. Their face was made in thin RC panels (of variable height in the different tiers, starting at 4.0 m and ending at 5.7 m) covering the entire height of a tier. They were reinforced by uniaxial integrally formed HDPE geogrids type 40RE to 120RE, applied in soil layers 0.4 m to 0.5m each, making together a structure known as GEOMUR®, Turcek *et al.* (2006). The embankment body was laid over a geoslab known as GEODOSKA®. The general view of the completed work is illustrated in Figure 1.

Figure 1. General view of three-tier surface geogrid reinforced wall

ARRANGEMENT OF THE GEOMUR® STRUCTURE AND GAUGES

As the motorway is considered a project of extraordinary importance, it was necessary to monitor the safety of the structure designed. The reliable functioning of the reinforced road bed was controlled by measuring of displacement of the geogrid used. According to a project of control activities, the plan was to gradually install deformation sensors at all three tiers of the reinforced embankment structure. The control works were intended to monitor and evaluate the displacement of multi-level extensometer rods in two measuring profiles. For long-term monitoring, two measuring profiles were selected: at km 6.610 and at km 6.956. Figure 2 illustrates the cross-section arrangement of the first measuring profile. In that profile, the embankment body is 12.2m high.

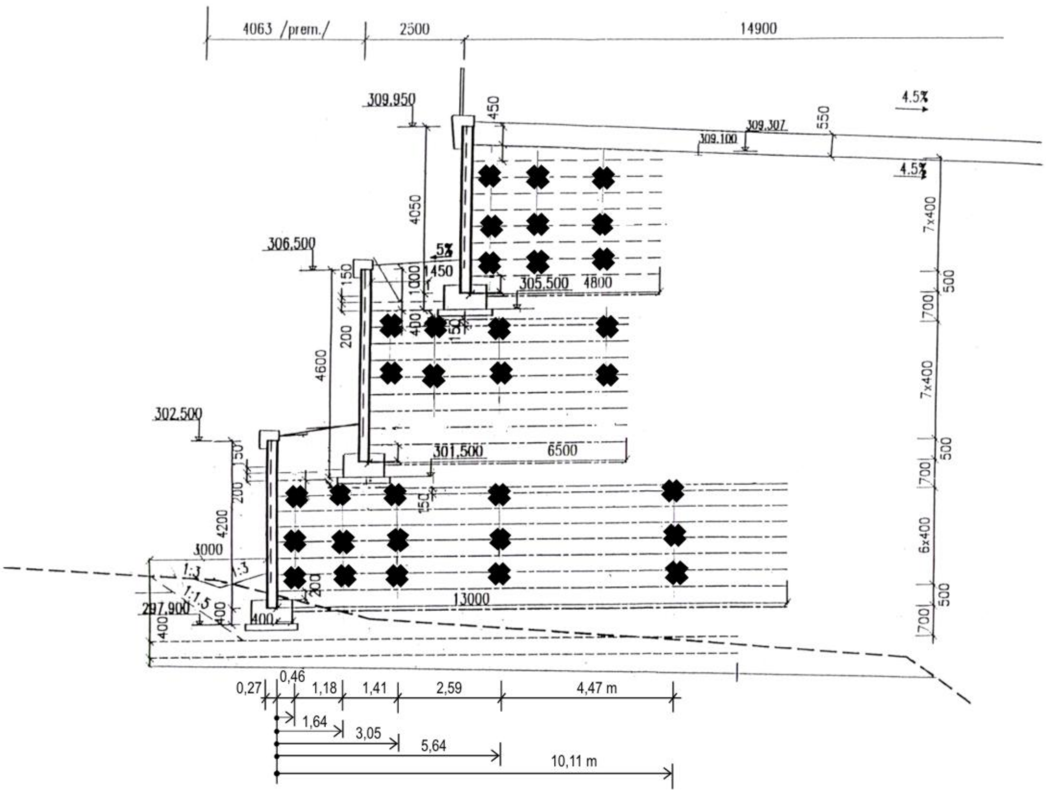

Figure 2. The 1st monitoring section

The displacement of the geogrid was monitored by five-level extensometer rods which observe changes in the distance between the extensometer anchor plate, firmly attached to the geogrid at the measuring point, and its nose fixed on the concrete panel face. Deformations were read on the airside of the panel, in a cover box, using a digital T-square gauge with a reading accuracy 0.01mm and measurement accuracy ± 0.05mm. The first sensors were installed in May 2001. The extensometers were installed under the measured geogrid layer and provided with protective sand filling 100mm thick. Over such protected measurement level, backfill was of gravel soils spread and compacted, as indicated in the project.

MEASUREMENT RESULTS

Displacement of the geogrids in time in different locations of measuring gauge are demonstrated on Fig.3 and 5 (Turcek 2007). Shortening of measuring bases are seen very often. As no tilting of facing panels towards soil body has been observed, this phenomenon must be the result of settlement of the layers of compacted soil. The credibility of measurements is proven by regular increase of deformations for measuring points more distant from the facing. Increasing of vertical load by filling of the soil body we could observe also regular growth of deformations. Gradual stabilisation and ceasing of deformations was depending on the position of measuring point. For higher load (measuring point was deeper in the soil body) this process was slower (e.g. see Fig. 4) than when the overburden was lower (Fig. 3). For vertical load approx. 40 kPa (wall height: 2m) deformations continued for 18 months, while for the load 240 kPa (wall height: 11.8 m) deformations were still developing after 30 months.

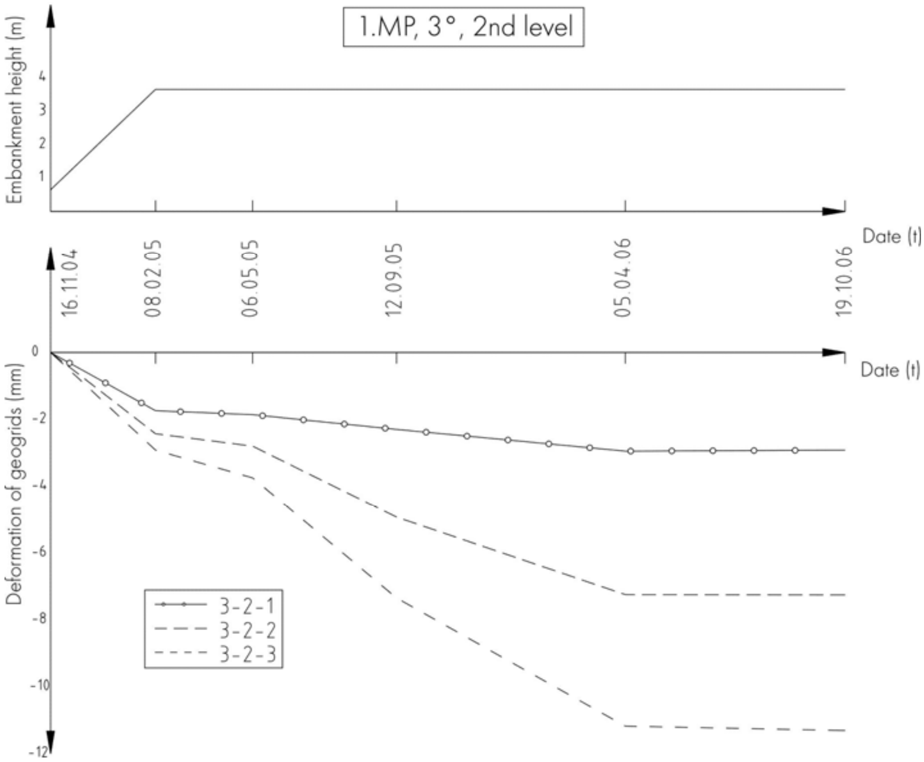

Figure 3. Displacement of the geogrid: MP 1, tier 3, level 2 in time

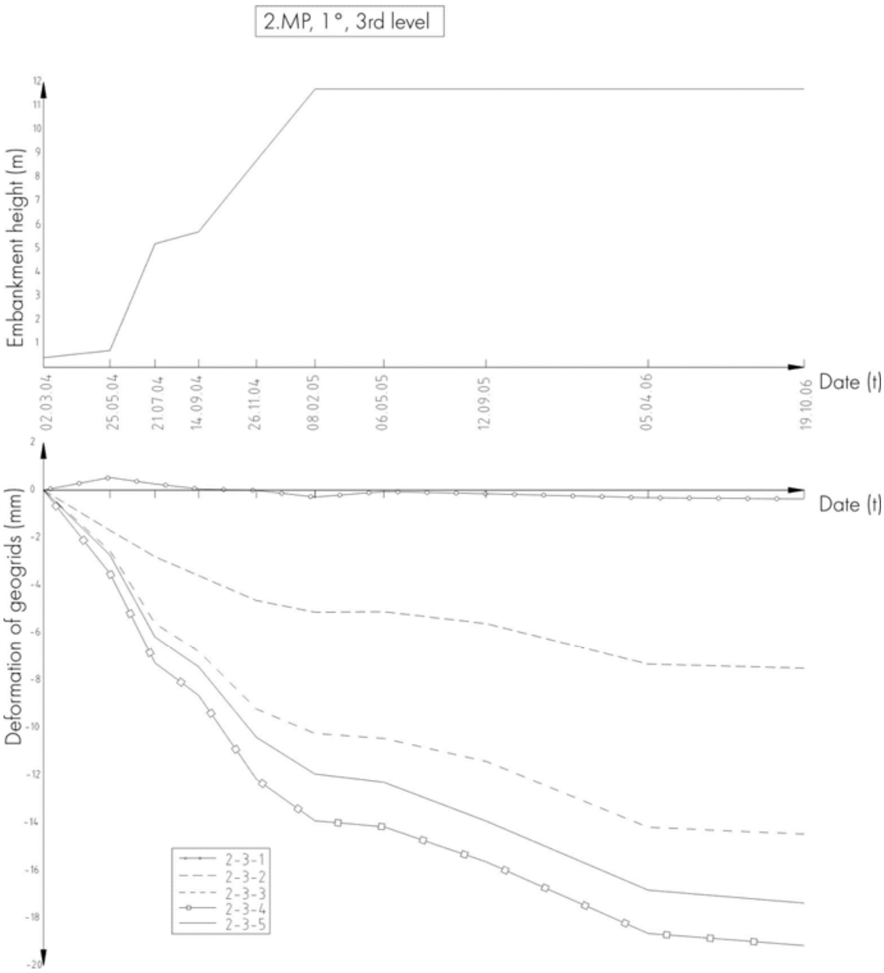

Figure 4. Displacement of the geogrid: MP 2, tier 1, level 3 in time

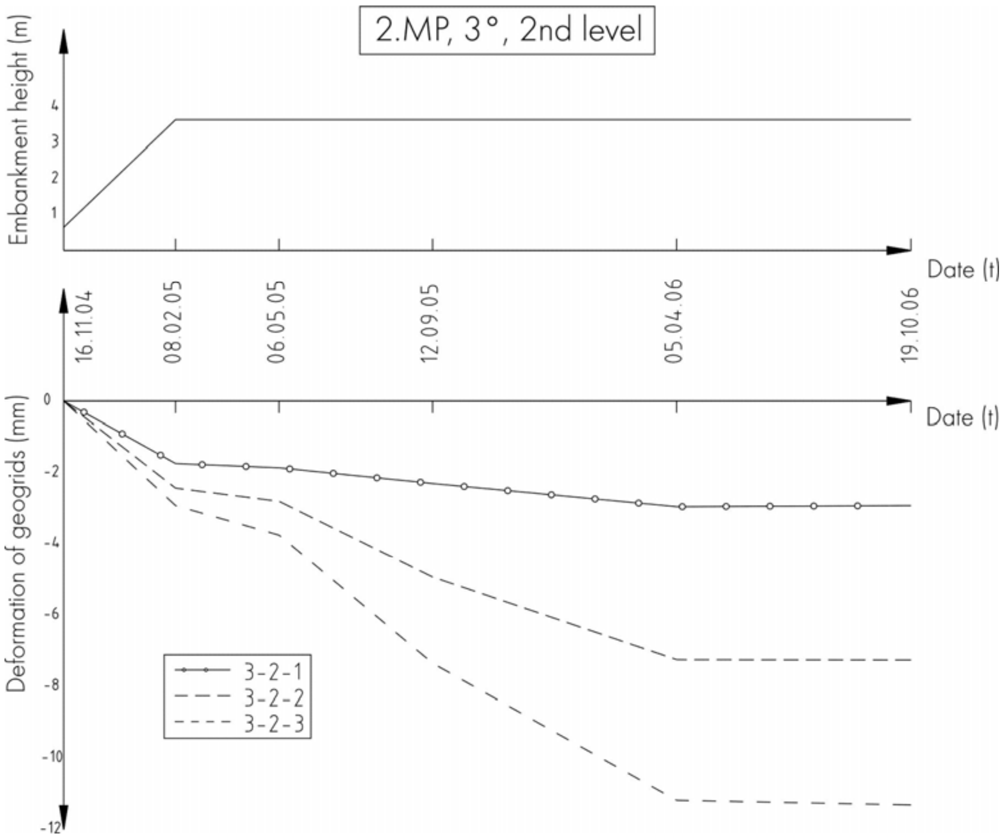

Figure 5. Displacement of the geogrid: MP 2, tier 3, level 2 in time

When evaluating the displacement of the geogrid at the various height levels, a relatively even increase in deformation with an increasing distance from the concrete panel can be observed. The measured values translated into strains are summarised in Table 1for all data measured.

Table 1. Strains between sensors

Measuring profile	Tier	Measuring level	Strains between sensors Δ/L (%)				
			0 – 1	1 – 2	2 – 3	3 – 4	4 – 5
1	1	1	0.065	0.065	0.091	0.045	0.105
		2	0.185	0.047	0.009	0.089	0.157
		3	0.154	0.045	0.124	0.119	0.062
	2	2	0.689	0.022	0.082	0.023	
		3	0.361	0.628	0.201	0.019	
	3	1	0.456	0.383	0.157		
		2	0.560	0.173	0.150		
		3	0.004	0.148	0.706		
2	1	3	0.053	0.593	0.291	0.186	0.062
	2	1	0.044	0.063	0.141	0.092	
		2	0.214	0.228	0.323	0.037	
		3	0.283	0.046	0.181	0.067	
	3	2	0.417	0.362	0.108		

The evaluation shows that all strains were less than 1 %. The largest strain was observed in measuring profile 1, tier 3, between sensors No. 2 and No. 3, with a value of 0.706 %. In 45 % of the data measured, strain was less than 0.1 %; in 69 % of measurements, strain was less than 0.2 %. All that is evidence of high rigidity of the reinforced soil structure.

From Table 1, strains from both measuring profiles were transposed into Fig. 6 and Fig. 7. As already pointed out during construction works (the remarks concerning lack of technological discipline) and in the above evaluations, the maximum strains have concentrated near the air face of the reinforced slope. Objectively, it is difficult to compact the embankment soil at the contact line with the concrete cladding panel. Moderately increased deformations in measuring profile 1, tier 1 were probably caused by unforeseeable technological breaks in construction, where the density of soils has been affected by the climate.

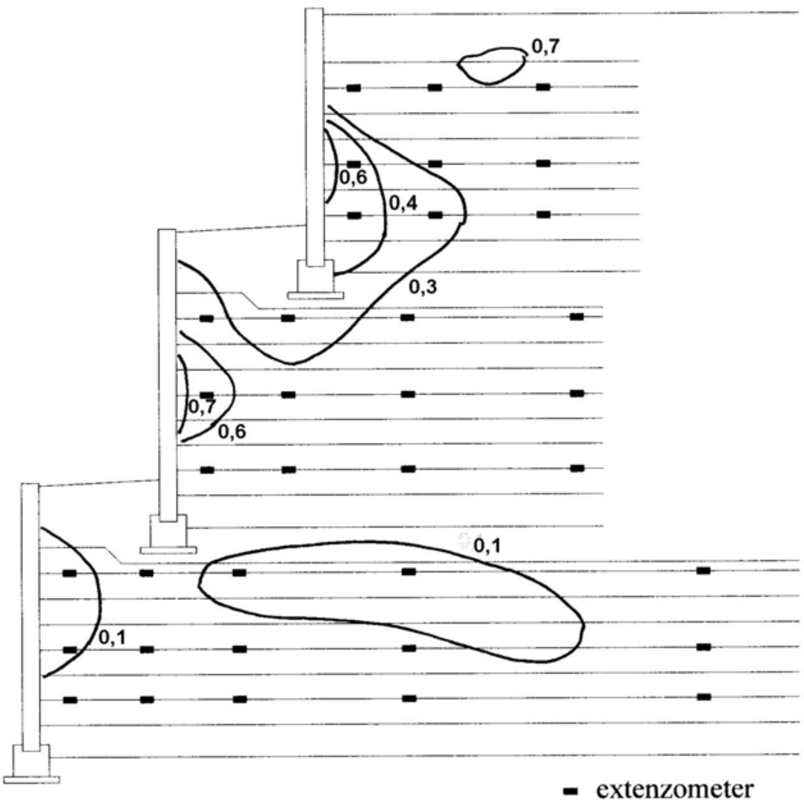

Figure 6. Strain isolines (%) in measuring profile 1

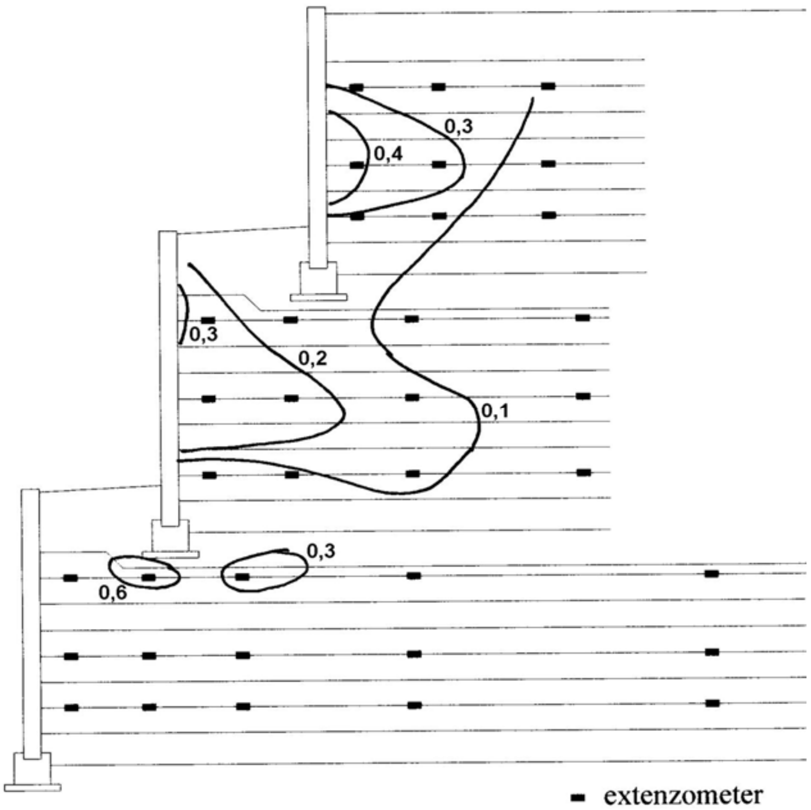

Figure 7. Strain isolines (%) in measuring profile 2

CONCLUSIONS

Monitoring of a reinforced embankment of unusual dimensions has brought a whole series of inspirations for the implementation team. A thorough preparation of the measuring project has transformed into information acquired which may be summarised as follows:

- The maximum strain value of the geogrid reaches a value of 0.706 % at a single point only; as that is the highest position of the entire embankment (the measured point is loaded by the embankment 0.6 m high and by the pavement), that displacement of the geogrid was attributed to compacting of the embankment soil.
- Strain less than 0.1 % was established in 45 % of measurements; strain less than 0.2 % was established in as many as 69 % of measurements. That confirms the high rigidity of the reinforced soil.
- The measured results were negatively affected by interruption of construction works and the unwillingness of the building constructor to respect requirements for compacting the road bed and protect the installed sensors (extensometers).
- It was established that – even though the road bed construction was interrupted for more than one year – it was appropriate to repeat the measurements. The measurements provided valuable data which confirmed that the data measured was correct on one hand, and allowed explaining the established anomalies on the other.

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REFERENCES

Turcek, P. 2007 . Evaluation of Monitoring of a Motorway Reinforced Retaining Wall near Sverepec. Expertize Report, 29 p.

Turcek, P., Turinic, L., Baslik, R. 2006. Highway three-tier surface geogrid reinforced wall. Proceedings 8th International Conference on Geosynthetics, Yokohama, IGS, 949-952.